

## NON GELATIN FILMS WITH IMPROVED BARRIER PROPERTIES

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Field of the Invention

This invention relates to modified polymeric materials and more particularly films of the modified cellulose material hydroxy propyl methyl cellulose (HPMC), and uses of such film.

Background of invention

HPMC is a synthetic plastics material, which is a chemically modified form of the naturally occurring polymer, cellulose. Films, (or sheets or membranes) of HPMC are available commercially and have various uses, including proposals for use as wall materials for delivery capsules i.e. capsules designed to retain and protect their contents until an intended site of delivery or conditions of delivery are encountered, at which the contents of the capsule are released. HPMC is suitable for ingestion by humans, so delivery capsules with HPMC walls find the potential use as ingestible capsules, e.g. for the delivery of accurately metered doses of pharmaceutical preparations and dietary supplements, as a possible replacement for gelatin based capsules. See for example, WO 97/35537, WO00/27367 and WO01/03676. HPMC can be used to encapsulate substances, such as pharmaceuticals or food supplements like fish oils. It is known that certain pharmaceuticals and food supplements can be prone to attack by extended exposure to e.g. air, and it is preferable to encapsulate many unrefined vegetable oils and fish oils to prevent them from going rancid. However, even when these substances are encapsulated, e.g. within HPMC film, they can still be prone to oxidation, e.g. by the film wall of the capsule allowing oxygen present in the air outside the capsule, to pass through into the inside of the capsule and coming into contact with the capsule's contents, and reacting in some way to spoil the contents.

HPMC has poor resistance to oxygen transmission relative to other hydrocolloid film forming materials, such as gelatin, alginates, pectins and some other natural polymers. To improve oxygen barrier properties of the HPMC film, the film can be coated with hydrocolloids, for example, alginates. However, the coating of these films does give rise to certain disadvantages, such as creating films with multiple layers of materials each layer perhaps possessing different physical/chemical properties and thus creating increased processing complexities and problems arising therefrom, resulting in an increase in time and costs for film production.

Glycols and acetins are already known as film additives for certain film materials, but untreated films and films treated with acetins and/or other additives can show very poor resistance to oxygen penetration. However, it has now been surprisingly

discovered that by incorporating various carboxylic acids, especially alpha hydroxy acids and beta hydroxy acids within HPMC film, it is possible to reduce the oxidation of vegetable and fish oils, and other oxidisable fill materials encapsulated in capsules made from this film.

It should be noted that this invention is not limited to simply HPMC film materials. HPC (hydroxy propyl cellulose), MHEC (methyl hydroxy ethyl cellulose), HEC (hydroxy ethyl cellulose), EHEC (ethyl hydroxy ethyl cellulose), EC (ethyl cellulose) and MC (methyl cellulose) are all materials which can be included.

#### Summary of the invention

In the widest scope the of the invention, further polymeric films are contemplated, within a group which can be defined as non-gelatin polymeric films.

In one aspect of the present invention provides hydroxypropyl methyl cellulose film, comprising hydroxypropyl methyl cellulose and an additive comprising an organic acid, or derivative or salt of such an acid.

Suitable organic acids are carboxylic acids, such as mono, di, tri, or tetra or other polyvalent carboxylic acids.

Carboxylic acids according to the present invention include the following:

C1-C6 saturated or unsaturated, straight or branched chain carboxylic acids, with 1,2,3 or 4 carboxyl groups

C1-C6 hydroxy acids with any combination of 1,2,3,4 hydroxyl/carboxyl groups, including alpha hydroxy acids (AHA's) and beta hydroxy acids (BHA's)

Cyclised acids and cyclised hydroxy acids

Specific examples of acids according to the present invention include the following:

#### **carboxylic acids**

Adipic acid

Fumaric acid

Maleic acid

Propionic acid

Salicylic acid

Ethanoic acid

Propanoic acid

Butanoic acid

Pentanoic acid  
Hexanoic acid

#### hydroxy acids

Alpha hydroxy butyric acid  
Mandelic acid  
Tartaric acid  
Lactic acid  
Citric acid  
Malic acid  
Glycolic acid  
Hydroxy citric acid

#### cyclised acids and cyclised hydroxy acids

Gamma butyrolactone  
Gamma valerolactone  
Beta propriolactone

HPMC films can be treated with alpha and beta hydroxy acids and also other carboxylic acids derived from fruit acids to produce clear films which can then be used to produce capsules which can significantly reduce oxidation of certain substances encapsulated within same as compared with capsules made from HPMC treated with compounds such as glycerine, propylene glycol, poly ethylene glycol and acetins. This significant improvement in the reduction of oxidation is thought to be attributable to the acid additive incorporated within the film perhaps hindering oxygen transmission through the film.

These films can be improved or modified further to suit the application by coating these films with aqueous solutions containing the acids according to the present invention.

Therefore, in a first aspect of the invention, the one or more acids are incorporated within the film by admixing the acids within a film forming resin which is then formed into a film.

In a second aspect of the invention, aqueous solutions of the acids are applied to the surface of a preformed film.

In a third aspect of the present invention, aqueous solutions of one or more acids are applied to the surface of films which are then bonded together.

In a fourth aspect of the present invention, aqueous solutions of one or more acids are applied to the surface of one or more capsule(s) made from film according to the present invention.

#### Film Manufacture

HPMC is dissolved in water with an acid or acids according to the present invention e.g. citric acid, to make a solution of which the total solids being between 10-20% w/w. (During this procedure, optional ingredients such as dyestuffs, sweeteners and manufacturing aids can be added.) The resultant viscous solution is then de-aerated and extruded at a set thickness onto a moving (endless) steel belt of which, during the length of its travel is heated to 80-100 degrees centigrade. During this heating process, water is evaporated from the film, leaving a dry film of thickness between 20-150 microns. This film is then removed from the belt and is further processed for use, e.g. slitting to a final roll width, laminating the single ply film to yield a double ply film, or coating with an external coat to give a specific desired property. Alternatively, for smaller quantities of film, a viscous solution can be poured onto a flat sheet of glass, and allowed to settle to form a flat bed of viscous liquid which lies on top of the glass. This can then be introduced into an oven at the desired temperature, where it can be left to dry, to form a desired sheet of film.

Alternatively to the above, a film can be formed as above but without the inclusion of the one or more acids within the film as the film is formed. Once the film has been formed, an aqueous solution of the one or more acids is applied to the surface of the film.

#### Preparation of capsules

A film solution consisting of HPMC and acid according to the present invention (total solids 10%) is cast onto glass plates to a set thickness. The cast film is then placed in a warm oven (50-80 degrees centigrade) to form a rigid film, which is then removed from the glass plate and left to equilibrate at room temperature. The resulting film produced is then placed on a vacuum forming bed and thermoformed into cavities or half capsules. Each cavity is filled (overfull) with fish or vegetable oil and lidded with

an identical sheet of HPMC film. A heated tool is then used to seal the films together and to cut the resulting capsules free of excess unused film surrounding the cavities. The capsules formed are removed from the bed and packed and placed in storage.

### Stability testing

The stability of fish and vegetable oils were evaluated in the capsules made in accordance with the present invention. The stability of the oil in the capsules was evaluated by analysing the peroxide value (P.V.) over time.

Using a standard pharmaceutical test, samples were prepared and stored in HDPE bottles at 30 degrees centigrade, 60% relative humidity. Periodically, the samples were removed and analysed according to method described in the European Pharmacopoeia: Peroxide Values Ph.Eur. method 2.5.5.

The results were plotted graphically to show comparative changes in P.V. over time.

Control capsules were made from HPMC film incorporating acetins (mono and diacetin).

The results can be interpreted thus: The higher rate of peroxide generated in the oil, the less stable is the end product.

Therefore, the best performing films show lower peroxide values.

## Formulations:

## Graph/fig. 1 , 2 and 4

	%w/w
HPMC (Methocel E50 ex Dow)	77
Diacetin	23

HPMC	77
Lactic acid	23

HPMC	77
Lactic acid	11
Citric acid	12

HPMC	77
Citric acid (anhydrous)	20
Glycerin	3

HPMC	77
Citric acid (anhydrous)	23

## Graph/fig 3

HPMC	77
Monoacetin	23

HPMC	77
Lactic acid	23

HPMC	77
Malic acid	23

HPMC	77
Citric acid	23

### Interpretation

#### Figure 1 – graph 1 capsules containing evening primrose oil (EPO)

Demonstrates the superior performance of HPMC incorporating citric acid or citric acid/glycerin combinations within the capsule film, by revealing generally lower and slowly rising peroxide values over a 5 month period. A 1:1 lactic/citric combination in the film still demonstrates very good performance and films treated solely with lactic acid still show a marked improvement over the performance of film treated with diacetin (control), a known film additive.

#### Figure 2 – graph 2 capsules containing fish oil (Lipromega TG60)

General trends shown in graph 1 are also demonstrated here. A vast improvement in maintaining low P.V. is shown. demonstrated by the stark stabilizing effect of citric acid.

#### Figure 3 – graph 3 capsules containing fish oil (Lipromega TG60).

In this test, capsules were exposed directly to the atmosphere (without any packaging around the capsules). HPMC films containing citric, malic and lactic acid (especially citric and malic acids) demonstrated superior performance with respect to peroxide values, over HPMC films containing monoacetin.

#### Figure 4 – graph 4 - Na Alginate coated HPMC film with various plasticisers encapsulating EPO.

Comparing this with graph 1, this shows additional stabilization of peroxide values, which can be maintained for a longer period of time, due to the sodium alginate coating on the HPMC film.